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PH3052 - Midterm 1

(8) 1. What are the four electromagnetic interactions with matter?

Reflection, Absorption, Transmission, Scattering

(12) 2. For reflection, if the incident angle is 0° , calculate the intensity of the reflected beam, assuming air ($n_1 = 1$) and glass ($n_2 = 1.6$)

$$R = \left(\frac{n_1 - n_2}{n_1 + n_2} \right)^2$$

$$R = \left(\frac{1.6 - 1}{1.6 + 1} \right)^2 = \left(\frac{0.6}{2.6} \right)^2 \\ = (0.23)^2 = 0.05 \text{ or } 5.3\%$$

Ans: _____ -

(10) 3. Calculate the energy (in eV), frequency (in Hz), and wavelength (in meters or microns) for the $n=4$ to $n=2$ transition in a hydrogen atom (note, $Z=1$).

$$E_n = Z^2 \frac{E_1}{n^2} \Rightarrow \text{for } n=2 \quad E_2 = \frac{-13.6}{2^2} = -3.4 \text{ eV};$$

$$\text{for } n=4 \quad E_4 = \frac{-13.6}{4^2} = \frac{-13.6}{16} = -0.84 \text{ eV}$$

$$E_{\text{photon}} = E_4 - E_2 = -0.84 + 3.4 = 2.55 \text{ eV}$$

$$f = \frac{E}{h} = \frac{2.55 \text{ eV}}{4.136 \times 10^{-15} \text{ eV-seconds}} = 6.16 \times 10^{14} \text{ Hz}$$

$$\lambda = \frac{c}{f} = \frac{3.0 \times 10^8}{6.16 \times 10^{14}} = 4.866 \times 10^{-7} = 4866 \text{ Angstroms} - \text{blue light}$$

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- (10) 4. Calculate the wavelength for the peak in radiation from a black body at $T = 728.84$ K, in microns, and the radiated power in Watts/m².

Wien's Law: $\lambda_{\max} = a/T$ $a = 2.898 \times 10^{-3} \text{ (m K)}$

$a = 2.898 \times 10^{-3} \text{ (m K)}$

$\lambda_{\max} = a/T = \frac{2.898 \times 10^{-3}}{728.84} = 4 \times 10^{-6} \text{ meters or 4 microns}$

$R = \sigma \epsilon T^4 = 5.67 \times 10^{-8} \cdot 1 \cdot (728.84)^4 = 5.67 \times 10^{-8} \cdot 2.82 \times 10^{11} = 16 \text{ kW/m}^2$

$\epsilon = \text{Emissivity}; \sigma = 5.67 \times 10^{-8} \left(\frac{\text{W}}{\text{m}^2 \text{ K}^4} \right); \quad T = \text{Temperature (K)}$

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(12). 5. Resolution questions. The first part of the question gives some information on a commercial remote sensing effort currently offered by Kodak under their CIITPIX™ program.

- Aircraft: Cessna Conquest 441
- Flight Altitude ~ 10,800 feet (3292 meters) above mean terrain
- Camera: **ZEISS RMK TOP 30** - Camera is equipped with TOPAR A3 normal-angle lens, focal length 305 mm (12"), angular field 56° (diagonal), aperture f/5.6 to f/22.
- Film: **KODAK AEROCOLOR II Negative Film 2445** - a very fine grain, medium-speed color negative film with resolving power of between 40 and 80 lines/mm depending on the contrast of the test target used. Film and camera enable resolution of features as small as 5.3 to 10.6 inches (13.5 cm to 27 cm). Film is sensitive in the visual spectral band between 350 and 700 nm. The film is 9.5" in width.

(6). a) So, if the lens is used "wide-open", which means at f5.6, what will the physical optics limit (Rayleigh Criteria) give for the best resolution at the given altitude (3292 meters), assuming the camera is nadir viewing? Use a wavelength in the middle of the spectral range for the film used here – e.g. 500 nm.

$$f/\# = \frac{\text{Focal Length}}{\text{Diameter}} \Rightarrow$$

$$\text{Diameter} = \frac{\text{Focal Length}}{f/\#} = \frac{0.305 \text{ meters}}{5.6} = 0.054 \text{ meters or } 54.5 \text{ mm}$$

$$\Delta\theta = \frac{\lambda}{\text{diameter}} = \frac{5 \times 10^{-7}}{5.45 \times 10^{-2}} = 9.2 \times 10^{-6} \text{ radians}$$

$$\text{GSD} = \Delta\theta \cdot \text{altitude} = 9.2 \times 10^{-6} \cdot 3292 = 3.0 \times 10^{-2} \text{ meters or } 3 \text{ cm}$$

(6). c) The usable film width is 9.0" (22.9 cm). Assuming square pictures (9.0" x 9.0"), what is the field of regard on the ground (x km by x km) ? What physical distance on the film corresponds to 13.5 cm (5.3 inches) on the ground?

$$\frac{\text{ground swath}}{\text{range}} = \frac{\text{film width}}{\text{focal length}} \Rightarrow \text{ground swath} = \frac{\text{film width}}{\text{focal length}} \cdot \text{range}$$

$$\text{ground swath} = \frac{0.229 \text{ m}}{0.305} \cdot 3292 = 2.47 \text{ km}$$

$$\frac{\text{GSD}}{\text{range}} = \frac{\text{film spot}}{\text{focal length}} \Rightarrow \text{film spot} = \frac{\text{GSD}}{\text{range}} \cdot \text{focal length}$$

$$\text{film spot} = \frac{13.5 \times 10^{-2} \text{ m}}{3292} \cdot 0.305 = 12.5 \times 10^{-6} \text{ m}, \text{ which is consistent with a film}$$

resolution of 40 lines/mm – which means one line, and a space, covers a distance of 25 microns,

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(8) 6. When was the first successful launch of a corona satellite mission ? What number was it ?

August 10, 1960, # 13

(9) 7. List what three (3) factors determine the ability of visible radiation to propagate through the atmosphere - or limit our ability to see through the atmosphere?

Scattering, turbulence, absorption

(11) 8. The bandgap for Indium Antimonide (InSb) is about 0.2 eV. Can this material be used for the detection of LWIR (8-13 microns) ? You need to do a calculation to justify your answer.

$$\lambda_{\text{cutoff}} = \frac{c}{f} = \frac{ch}{E} = \frac{3.0 \times 10^8 \frac{\text{m}}{\text{s}} \bullet 4.136 \times 10^{-15} \text{ eV-seconds}}{0.2 \text{ eV}}$$

$$= \frac{1.24 \times 10^{-6}}{0.2} = 6.2 \mu$$

this wavelength is short of the LWIR range, which starts at 8 microns.
So the answer is No.

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(12) 9. List 6 of the elements of recognition (2 pts each):
size, shape, texture, site, association, shadow, tone/color

(8 pts) 10. The USS Constellation is 1073 ft long, (315 1-meter pixels in this image), and has an extreme beam of 282 feet. (IKONOS, 07 February 2000) and <http://www.nvr.navy.mil/nvrships/details/CV64.htm>
Which of the above elements of recognition would help you identify the ship behind it?
How/why?

Size: given the size of the carrier, however obtained, one can calculate the size of the ship at the stern of the Constellation. The latter ship is 242 pixels long, or 242 meters in length



Association: You might assume that the two ships are part of the same battle group. A CV is usually accompanied by a DDG or FFG, though this one is a little large to be such. What supply ships travel with the Constellation? Oilers moor at this pier.

Shape: It's not a cigarette boat. Compare to photo-recognition books given to pilots

Pattern: spacing of masts, and other superstructure elements is pretty much a unique identifier.

Site: It's in a harbor – given more information on that location would tell you something about it. Here San Diego, Feb 7, 2000. Given that carriers are big enough to be tracked, you would know where the Constellation was at almost any time.
Deep draft harbor? Tells you something about the nature of ships which will tie up at this dock.

Texture- the patterns on the deck indicate some sort of cargo ship.

Shadows – gives you the height of the structures on the deck.